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Research Article

Augmented Reality in Sustainable Space Planning: Qualitative Perspectives from Practitioners and Clients

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Abstract

Augmented Reality (AR) is increasingly recognised as a transformative technology in sustainable space planning, offering innovative solutions for visualisation, stakeholder engagement, and decision-making. This study explores the role of AR through a qualitative analysis of secondary data, drawing on peer-reviewed literature, case studies, and documented practitioner and client experiences. The findings indicate that AR significantly enhances spatial understanding by enabling real-time, context-aware visualisation of design proposals. It also fosters participatory planning by improving communication and collaboration among diverse stakeholders. Furthermore, AR contributes to environmental, social, and economic sustainability by supporting simulation-based analysis, inclusive engagement, and efficient design processes. However, challenges such as technological complexity, high implementation costs, accessibility issues, and ethical concerns related to data privacy remain barriers to widespread adoption. The study integrates the Technology Acceptance Model, Participatory Planning Theory, and the Triple Bottom Line framework to develop a comprehensive understanding of AR's impact. Overall, the research highlights the potential of AR to transform sustainable planning practices while emphasising the need for strategic implementation and policy support.

Keywords: augmented reality, sustainable space planning, participatory planning, urban design, digital visualisation, stakeholder engagement, smart cities.

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1. Introduction

Sustainable space planning has emerged as a critical priority in the 21st century, driven by rapid urbanisation, climate change, and increasing demands for equitable and efficient use of spatial resources. Urban areas are expanding at unprecedented rates, particularly in developing countries, creating complex challenges related to environmental degradation, infrastructure strain, and social inequality (UN-Habitat, 2020). In this context, planners, architects, and policymakers are required to adopt innovative approaches that integrate sustainability principles into spatial design and decision-making processes.

Traditional methods of space planning have relied heavily on two-dimensional drawings, physical models, and static digital visualisations. While these tools have been effective to a certain extent, they often fail to provide a comprehensive understanding of spatial transformations, particularly for non-expert stakeholders. This limitation can lead to communication gaps, misinterpretation of design proposals, and reduced stakeholder engagement (Whyte, 2002). As planning processes become increasingly participatory, there is a growing need for tools that can bridge the gap between technical expertise and public understanding.

Augmented Reality (AR) has emerged as a transformative technology capable of addressing these challenges. AR overlays digital content onto the physical environment, enabling users to interact with virtual elements in real time while

maintaining awareness of the real world (Azuma, 1997). This capability enhances spatial cognition and allows stakeholders to visualise proposed interventions within their actual context. Unlike Virtual Reality (VR), which immerses users in a completely simulated environment, AR integrates digital information into the existing physical setting, making it particularly suitable for applications in spatial planning and urban design.

The application of AR in sustainable space planning has gained increasing attention in recent years. AR technologies enable planners to simulate environmental impacts, assess design alternatives, and engage stakeholders in more meaningful ways. For example, AR can be used to visualise the impact of proposed buildings on sunlight exposure, green space, and urban aesthetics, thereby supporting more informed decision-making (Alazzawi & Alsamer, 2024). Additionally, AR facilitates real-time collaboration among stakeholders, allowing them to explore design options and provide feedback interactively.

One of the key advantages of AR in planning is its ability to enhance stakeholder engagement. Participatory planning is widely recognised as a fundamental component of sustainable development, as it ensures that diverse perspectives are considered in decision-making processes (Healey, 1997). However, traditional participatory methods often struggle to effectively communicate complex spatial information. AR addresses this limitation by providing intuitive and immersive visualisations that are accessible to a wide range of stakeholders, including

clients, community members, and decision-makers (Othengrafen et al., 2023).

Moreover, AR has the potential to contribute to the three pillars of sustainability, environmental, social, and economic, commonly referred to as the Triple Bottom Line (Elkington, 1997). Environmentally, AR can support the analysis of ecological impacts and promote resource-efficient design. Socially, it fosters inclusive participation and enhances transparency in planning processes. Economically, AR can reduce costs associated with design revisions and improve project efficiency by enabling early identification of potential issues.

Despite these benefits, the adoption of AR in sustainable space planning is not without challenges. Technological limitations, high implementation costs, and issues related to data integration and interoperability remain significant barriers (Portman et al., 2015). Furthermore, there are concerns regarding the accessibility of AR technologies, particularly in developing regions where digital infrastructure may be limited. Ethical considerations, such as data privacy and the potential for technological bias, also require careful attention.

While a growing body of research has explored the technical capabilities and applications of AR in planning, there is a notable gap in understanding the qualitative experiences of practitioners and clients who interact with these technologies. Most studies focus on experimental or prototype-based applications, with limited attention to real-world implementation and stakeholder perspectives. Understanding these perspectives is crucial for assessing the

practical value of AR and identifying strategies for its effective integration into sustainable planning practices.

This study seeks to address this gap by exploring the role of AR in sustainable space planning through a qualitative analysis of secondary data. By examining existing literature, case studies, and documented experiences, the research aims to provide a comprehensive understanding of how AR is perceived and utilised by practitioners and clients. The study also seeks to develop a theoretical framework that links AR affordances with sustainability outcomes, thereby contributing to both academic knowledge and practical applications.

The research is guided by the following objectives:

- To examine the role of AR in enhancing sustainable space planning practices.
- To analyse practitioner and client perspectives on the use of AR.
- To identify the benefits and challenges associated with AR adoption.
- To develop a conceptual framework linking AR capabilities with sustainability principles.

By addressing these objectives, the study contributes to the ongoing discourse on digital transformation in spatial planning and highlights the potential of AR as a tool for achieving more sustainable and inclusive urban environments.

2. Literature Review

Augmented Reality (AR) is defined as a technology that combines real and virtual elements, is interactive in real time, and operates in three-dimensional space (Azuma, 1997). Over the past two decades, AR has evolved significantly, driven by advancements in mobile computing, computer vision, and sensor technologies. Modern AR systems are capable of delivering highly immersive and context-aware experiences, making them suitable for a wide range of applications.

AR differs fundamentally from Virtual Reality (VR) in that it does not replace the real environment but enhances it with digital overlays. This characteristic makes AR particularly relevant for spatial planning, where maintaining a connection to the physical environment is essential. According to Milgram and Kishino (1994), AR exists on a continuum between the real and virtual worlds, providing a hybrid environment that supports both perception and interaction.

The core features of AR, visualisation, interactivity, and immersion, are central to its application in planning contexts. Visualisation allows users to perceive spatial information more effectively, interactivity enables engagement with digital content, and immersion enhances the overall user experience. These features collectively contribute to improved understanding and decision-making.

2.1 AR in Urban Planning and Design

The integration of AR into urban planning and design has been widely explored in

recent literature. AR technologies enable planners to create interactive representations of urban environments, facilitating better communication and collaboration among stakeholders.

One of the primary applications of AR in urban planning is visualisation. Traditional planning tools often rely on abstract representations that may be difficult for non-experts to interpret. AR addresses this limitation by providing realistic and context-specific visualisations that enhance spatial understanding (Portman et al., 2015). For example, AR can be used to overlay proposed buildings onto existing landscapes, allowing stakeholders to assess their visual impact in real time.

In addition to visualisation, AR supports participatory planning processes by enabling stakeholders to engage with design proposals more effectively. Research indicates that AR-based tools can increase public participation and improve the quality of stakeholder interactions (Othengrafen et al., 2023). By making planning scenarios more accessible and understandable, AR fosters inclusive decision-making and enhances transparency.

Furthermore, AR has been shown to improve design efficiency and decision-making. By enabling real-time evaluation of design alternatives, AR allows planners to identify potential issues and make informed decisions early in the design process (Alazzawi & Alsamer, 2024). This can lead to reduced costs and improved project outcomes.

2.2 AR and Sustainable Development

Sustainability is a central concern in contemporary planning, encompassing environmental, social, and economic dimensions. AR has the potential to contribute to all three dimensions by enhancing the planning process and supporting more informed decision-making.

From an environmental perspective, AR can be used to simulate the impacts of design interventions on natural systems. For example, AR applications can visualise changes in sunlight exposure, energy consumption, and green space distribution, enabling planners to assess the environmental implications of their decisions (You et al., 2022). This supports the development of more sustainable and resource-efficient designs.

Socially, AR enhances stakeholder engagement by providing intuitive and interactive tools for participation. Participatory planning is widely recognised as a key component of sustainable development, as it ensures that diverse perspectives are considered in decision-making processes (Healey, 1997). AR facilitates this by making complex spatial information more accessible to non-experts.

Economically, AR can improve efficiency and reduce costs by enabling early identification of design issues and minimising the need for costly revisions. Additionally, AR can enhance project communication, reducing misunderstandings and delays.

The integration of AR into sustainable planning aligns with the concept of smart cities, where digital technologies are used to improve urban management and quality of life (Batty et al., 2012). AR contributes to this vision by enabling more efficient and informed planning processes.

2.3 Stakeholder Perspectives and User Experience

Understanding stakeholder perspectives is essential for evaluating the effectiveness of AR in planning. Practitioners, including planners and architects, often view AR as a valuable tool for enhancing design communication and decision-making. Clients and community members, on the other hand, benefit from improved understanding and engagement.

Research suggests that AR can enhance user experience by providing immersive and interactive environments that facilitate learning and collaboration (Beheshti et al., 2024). Users are more likely to engage with planning processes when they can visualise and interact with proposed changes in a meaningful way.

However, user acceptance of AR is influenced by factors such as perceived usefulness and ease of use, as described in the Technology Acceptance Model (Davis, 1989). If AR tools are perceived as complex or difficult to use, their adoption may be limited. Therefore, usability and accessibility are critical considerations in the development and implementation of AR applications.

2.4 Challenges and Limitations of AR in Planning

Despite its potential, AR faces several challenges that may hinder its widespread adoption. One of the primary challenges is the high cost of implementation, including hardware, software, and data integration. These costs may be prohibitive for smaller organisations or projects.

Technical limitations, such as issues with tracking accuracy, data quality, and system compatibility, also pose significant challenges (Portman et al., 2015). In addition, the integration of AR with existing planning systems and workflows can be complex.

Accessibility is another important concern, particularly in developing regions where digital infrastructure may be limited. Ensuring that AR technologies are accessible to a wide range of stakeholders is essential for promoting inclusive planning.

Ethical considerations, including data privacy and the potential for technological bias, must also be addressed. As AR systems rely on large amounts of data, ensuring the security and ethical use of this data is critical.

2.5 Research Gap

While the existing literature highlights the potential of AR in sustainable planning, there are several gaps that require further investigation. First, there is limited research on the qualitative experiences of practitioners and clients, particularly in real-world contexts. Second, the integration of AR within broader sustainability frameworks remains underexplored. Finally, there is a need for more comprehensive studies that

examine both the benefits and challenges of AR adoption.

This study addresses these gaps by analysing secondary qualitative data to explore stakeholder perspectives and develop a conceptual framework linking AR capabilities with sustainability outcomes.

3. Theoretical Framework

The integration of Augmented Reality (AR) into sustainable space planning necessitates a robust theoretical foundation that captures both technological adoption and the socio-spatial dynamics of planning processes. This study draws upon three complementary theoretical perspectives: the Technology Acceptance Model (TAM), Participatory Planning Theory, and the Triple Bottom Line (TBL) framework. Together, these frameworks provide a multidimensional lens through which AR's role in sustainable planning can be examined.

3.1 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Davis (1989), is one of the most widely used frameworks for understanding user adoption of new technologies. TAM posits that two primary factors, perceived usefulness and perceived ease of use, determine an individual's intention to use a technology, which in turn influences actual usage behaviour.

In the context of AR in sustainable space planning, perceived usefulness refers to the extent to which practitioners and clients believe that AR enhances planning outcomes.

This may include improved visualisation, better communication of design concepts, and more effective decision-making. Studies have shown that AR can significantly enhance spatial understanding and reduce ambiguity in design interpretation, thereby increasing its perceived usefulness (Alazzawi & Alsamer, 2024).

Perceived ease of use, on the other hand, relates to the usability and accessibility of AR systems. If AR tools are complex, require specialised training, or involve technical barriers, users may be less inclined to adopt them. This is particularly relevant in planning contexts where stakeholders may have varying levels of technical expertise. Research suggests that user-friendly interfaces and intuitive interaction mechanisms are critical for promoting AR adoption (Davis, 1989; Beheshti et al., 2024).

Furthermore, extensions of TAM, such as TAM2 and the Unified Theory of Acceptance and Use of Technology (UTAUT), highlight the role of social influence and facilitating conditions in technology adoption (Venkatesh et al., 2003). In planning contexts, these factors may include organisational support, availability of resources, and peer influence among professionals. Thus, TAM provides a valuable framework for understanding how and why AR is adopted in sustainable space planning.

3.2 Participatory Planning Theory

Participatory planning theory emphasises the importance of stakeholder involvement in decision-making processes. Rooted in communicative planning theory, it advocates

for inclusive, transparent, and collaborative approaches to planning that incorporate diverse perspectives (Healey, 1997).

AR aligns closely with the principles of participatory planning by enabling more effective communication and engagement among stakeholders. Traditional planning methods often rely on technical representations that may be difficult for non-experts to interpret. AR addresses this limitation by providing immersive and interactive visualisations that make complex spatial information more accessible (Othengrafen et al., 2023).

From a theoretical perspective, AR can be seen as a tool that enhances communicative rationality, a concept introduced by Habermas (1984), which emphasises the role of dialogue and mutual understanding in decision-making. By enabling stakeholders to visualise and interact with planning scenarios, AR facilitates more informed discussions and collaborative problem-solving.

Moreover, participatory planning theory highlights the importance of empowerment and equity in planning processes. AR contributes to these objectives by democratizing access to information and enabling stakeholders to actively participate in design and decision-making. This is particularly important in sustainable planning, where the inclusion of diverse perspectives is essential for achieving socially equitable outcomes.

3.3 Triple Bottom Line (TBL) Framework

The Triple Bottom Line (TBL) framework, introduced by Elkington (1997), provides a comprehensive approach to sustainability by considering three interconnected dimensions: environmental, social, and economic. This framework is widely used in sustainable planning to evaluate the impacts of development projects.

AR contributes to the environmental dimension by enabling the simulation and analysis of ecological impacts. For example, AR can be used to visualise energy consumption, carbon emissions, and the effects of design interventions on natural systems (You et al., 2022). This supports the development of environmentally sustainable designs.

In terms of the social dimension, AR enhances stakeholder engagement and promotes inclusive decision-making. By making planning processes more accessible and transparent, AR fosters social sustainability and strengthens community participation (Othengrafen et al., 2023).

The economic dimension of TBL is addressed through the efficiency gains associated with AR. By enabling early identification of design issues and reducing the need for revisions, AR can lower project costs and improve resource allocation. Additionally, AR can enhance project communication, reducing delays and misunderstandings.

3.4 Integration of Theoretical Perspectives

The integration of TAM, participatory planning theory, and the TBL framework provides a holistic understanding of AR's role in sustainable space planning. TAM explains the factors influencing the adoption of AR, participatory planning theory highlights its role in enhancing stakeholder engagement, and TBL provides a framework for evaluating its sustainability impacts.

This study proposes a conceptual model in which:

- AR affordances (visualisation, interactivity, immersion)
- Influence user perceptions (usefulness, ease of use)
- Enhance stakeholder engagement and collaboration
- Lead to improved sustainability outcomes (environmental, social, economic)

This integrated framework serves as the foundation for analysing qualitative data and interpreting the findings of the study.

4. Research Methodology

This study adopts a qualitative research design based on secondary data analysis to explore the role of Augmented Reality in sustainable space planning. Qualitative research is particularly well-suited for examining complex phenomena, as it enables in-depth exploration of experiences, perceptions, and contextual factors (Creswell & Poth, 2018).

The use of secondary data enables the researcher to draw on a wide range of existing studies, case reports, and documented experiences. This approach is appropriate given the exploratory nature of the study and the need to synthesise insights from diverse sources.

4.1 Research Approach

The study follows an interpretivist research paradigm, which emphasises understanding social phenomena from the perspectives of individuals and groups. Interpretivism is particularly relevant for this study, as it focuses on the subjective experiences of practitioners and clients using AR in planning contexts (Schwandt, 2014).

By adopting this approach, the study seeks to:

- Understand how stakeholders perceive AR
- Explore their experiences and challenges
- Interpret the meanings they assign to AR applications

4.2 Data Sources and Selection Criteria

The study utilises secondary qualitative data from multiple sources, including:

- Peer-reviewed journal articles
- Conference proceedings
- Case studies
- Industry reports

A systematic approach was used to select relevant sources. The inclusion criteria were:

- Studies focusing on AR in planning, architecture, or design

- Research addressing sustainability or stakeholder engagement
- Publications providing qualitative insights or case-based evidence

Sources published between 2010 and 2025 were prioritised to ensure relevance and currency.

4.3 Data Collection Process

Data collection involved a systematic literature review, following established guidelines for qualitative synthesis (Snyder, 2019). The process included:

- Identification of relevant databases (e.g., Scopus, Web of Science, Google Scholar)
- Use of keywords such as “Augmented Reality,” “sustainable planning,” “urban design,” and “stakeholder engagement”
- Screening of titles and abstracts
- Full-text review of selected articles

The selected studies were then analysed to extract qualitative data related to practitioner and client perspectives.

4.4 Data Analysis Technique

The study employs thematic analysis, a widely used method for analysing qualitative data (Braun & Clarke, 2006). The process involved the following steps:

Familiarisation: The researcher reviewed the selected studies to gain an overall understanding of the data.

Coding: Relevant data segments were coded based on key themes, such as:

- Visualisation and design communication
- Stakeholder engagement
- Decision-making processes
- Sustainability outcomes
- Challenges and limitations

Theme Development: Codes were grouped into broader themes that capture recurring patterns across the data.

Interpretation: The themes were interpreted in relation to the theoretical framework, allowing for a deeper understanding of AR's role in sustainable planning.

4.5 Reliability and Validity

To ensure the rigour of the study, several strategies were employed:

- **Credibility:** Use of multiple sources and cross-referencing of findings
- **Dependability:** Transparent documentation of the research process
- **Confirmability:** Objective interpretation of data, supported by evidence
- **Transferability:** Detailed description of context to enable application to other settings (Lincoln & Guba, 1985)

4.6 Ethical Considerations

As the study relies on secondary data, ethical concerns are minimal. However, the following principles were observed:

- Proper citation of all sources
- Avoidance of plagiarism
- Respect for intellectual property rights (Mannan & Farhana, 2026)

No primary data involving human participants were collected, eliminating the need for ethical approval.

4.6 Limitations of the Methodology

While secondary qualitative analysis provides valuable insights, it has certain limitations:

- Dependence on the quality and scope of existing studies
- Lack of direct interaction with participants
- Potential bias in the interpretation of data

Despite these limitations, the methodology is appropriate for the exploratory nature of the study and provides a comprehensive understanding of AR in sustainable planning.

5. Findings and Analysis

The thematic analysis of secondary qualitative data reveals several interrelated themes that illustrate how Augmented Reality (AR) is shaping sustainable space planning. These themes include enhanced spatial visualisation, improved stakeholder engagement, decision-making efficiency, contributions to sustainability, and persistent technological and institutional challenges. The findings synthesise practitioner and client perspectives drawn from case studies, empirical research, and documented applications of AR in planning contexts.

5.1 Enhanced Spatial Visualisation and Cognitive Understanding

One of the most prominent findings is the transformative role of AR in improving

spatial visualisation and cognitive comprehension. Traditional planning tools, such as 2D drawings, GIS maps, and physical models, often fail to communicate the experiential and spatial qualities of proposed developments, particularly to non-expert stakeholders (Whyte, 2002). AR addresses this limitation by enabling real-time, in-situ visualisation of design proposals, thereby enhancing users' ability to perceive spatial relationships and scale.

Practitioners report that AR facilitates a more intuitive understanding of complex design elements, including building massing, spatial configurations, and environmental impacts. By overlaying digital models onto real-world environments, AR allows users to experience proposed changes as if they were already implemented. This immersive visualisation significantly reduces ambiguity and misinterpretation, which are common in conventional planning processes (Portman et al., 2015).

From a cognitive perspective, AR enhances spatial cognition by providing multimodal sensory input, including visual, auditory, and interactive elements. This aligns with constructivist learning theories, which emphasise the importance of experiential learning in knowledge acquisition (Kolb, 1984). Clients and community stakeholders, who may lack technical expertise, particularly benefit from AR's ability to translate abstract design concepts into tangible experiences.

Furthermore, AR enables dynamic visualisation of temporal changes, such as daylight variations, seasonal effects, and urban growth scenarios. This capability

allows stakeholders to evaluate long-term implications of planning decisions, thereby supporting more sustainable outcomes (You et al., 2022).

5.2 Improved Stakeholder Engagement and Participatory Processes

Another key finding is the significant impact of AR on stakeholder engagement and participatory planning. Participatory planning is widely recognised as essential for achieving sustainable and inclusive urban development (Healey, 1997). However, traditional engagement methods often struggle to effectively communicate complex spatial information, leading to limited participation and inequitable outcomes.

AR enhances stakeholder engagement by making planning processes more accessible, interactive, and engaging. Studies indicate that AR-based tools increase motivation for participation and improve the quality of stakeholder interactions (Othengrafen et al., 2023). By enabling users to visualise and interact with planning scenarios, AR fosters a sense of ownership and involvement among stakeholders.

Practitioners report that AR facilitates more productive discussions during public consultations, as stakeholders are better able to understand and evaluate design proposals. Clients also benefit from improved communication with designers, as AR reduces the reliance on technical jargon and abstract representations.

Moreover, AR supports collaborative decision-making by enabling multiple

stakeholders to interact with the same virtual environment simultaneously. This shared experience promotes dialogue, negotiation, and consensus-building, which are critical components of participatory planning (Habermas, 1984).

However, the findings also highlight disparities in access to AR technologies, which may limit participation among certain groups. Ensuring equitable access to AR tools is therefore essential for realising their full potential in participatory planning.

5.3 Decision-Making Efficiency and Design Optimisation

The analysis reveals that AR significantly enhances decision-making efficiency and design optimisation in sustainable space planning. By enabling real-time evaluation of design alternatives, AR allows stakeholders to identify potential issues and make informed decisions early in the planning process.

Practitioners emphasise that AR reduces the need for iterative design revisions by providing immediate feedback on design proposals. This not only saves time and resources but also improves the overall quality of planning outcomes (Alazzawi & Alsamer, 2024). For example, AR can be used to assess the visual impact of buildings, evaluate pedestrian flow, and analyse environmental factors such as shading and wind patterns.

Clients also report increased confidence in decision-making when using AR, as they can visualise the outcomes of different design options. This reduces uncertainty and enhances trust in the planning process.

Additionally, AR supports scenario-based planning by enabling stakeholders to explore multiple design alternatives and evaluate their implications. This aligns with systems thinking approaches, which emphasise the importance of considering complex interactions and feedback loops in planning (Batty et al., 2012).

5.4 Contributions to Environmental, Social, and Economic Sustainability

AR's contributions to sustainability are evident across the three dimensions of the Triple Bottom Line (Elkington, 1997).

Environmental Sustainability: AR enables the simulation and visualisation of environmental impacts, such as energy consumption, carbon emissions, and ecological changes. This allows planners to assess the sustainability of design proposals and make environmentally informed decisions (You et al., 2022). For instance, AR can be used to visualise the impact of green infrastructure, assess solar potential, and evaluate urban heat island effects.

Social Sustainability: AR enhances social sustainability by promoting inclusive participation and improving communication among stakeholders. By making planning processes more transparent and accessible, AR fosters trust and collaboration, which are essential for achieving equitable outcomes (Othengrafen et al., 2023).

Economic Sustainability: AR contributes to economic sustainability by improving efficiency and reducing costs. By enabling early identification of design issues and

minimising the need for revisions, AR can significantly reduce project costs. Additionally, improved communication and decision-making can lead to more successful project outcomes.

5.5 Challenges and Limitations

Despite its benefits, AR faces several challenges that may hinder its widespread adoption in sustainable space planning.

Technological Challenges: Technical limitations, such as tracking accuracy, data quality, and system compatibility, remain significant barriers (Portman et al., 2015). These issues can affect the reliability and usability of AR applications.

Economic Barriers: The high cost of AR hardware, software, and implementation can be prohibitive, particularly for smaller organisations and projects.

Accessibility Issues: Limited access to AR technologies may exclude certain stakeholders, particularly in developing regions with inadequate digital infrastructure.

Ethical Concerns: Issues related to data privacy, security, and technological bias must be addressed to ensure ethical use of AR.

Overall, the findings demonstrate that AR has significant potential to transform sustainable space planning by enhancing visualisation, engagement, and decision-making. However, addressing the identified challenges is essential for realising this potential.

6. Discussion

The findings of this study provide important insights into the role of Augmented Reality

(AR) in sustainable space planning, highlighting both its transformative potential and its limitations. This section interprets the findings in relation to the theoretical framework and broader literature, offering a deeper understanding of AR's implications for planning practice and sustainability.

6.1 AR and Technology Adoption: Insights from TAM

The findings strongly support the Technology Acceptance Model (TAM), as both practitioners and clients perceive AR as a useful tool for enhancing planning outcomes. The ability of AR to improve visualisation, communication, and decision-making contributes to its perceived usefulness, which is a key determinant of technology adoption (Davis, 1989).

However, the findings also highlight challenges related to perceived ease of use, particularly for non-expert users. Complex interfaces and technical requirements may hinder adoption, emphasising the need for user-friendly design and training (Venkatesh et al., 2003).

6.2 AR as a Tool for Participatory Planning

The study reinforces the relevance of participatory planning theory, demonstrating how AR enhances stakeholder engagement and collaboration. By providing immersive and interactive experiences, AR facilitates more effective communication and understanding among stakeholders.

From a communicative planning perspective, AR supports the development of shared understanding and consensus-building,

which are essential for sustainable planning (Habermas, 1984; Healey, 1997). However, the digital divide remains a significant challenge, as unequal access to AR technologies may limit participation.

6.3 AR and Sustainability: A Triple Bottom Line Perspective

The findings highlight AR's contributions to environmental, social, and economic sustainability, consistent with the Triple Bottom Line framework (Elkington, 1997).

- **Environmental:** AR supports environmentally informed decision-making through simulation and visualisation.
- **Social:** AR enhances inclusivity and transparency in planning processes.
- **Economic:** AR improves efficiency and reduces costs.

However, the sustainability benefits of AR depend on its effective implementation and integration into planning processes.

6.4 Implications for Practice

The study has several practical implications for planners, architects, and policymakers:

- **Integration of AR into Planning Workflows:** AR should be integrated into existing planning processes to enhance efficiency and effectiveness.
- **Capacity Building:** Training programs are needed to improve user skills and promote adoption.
- **Policy Support:** Policymakers should develop frameworks to support the use of AR in planning.

- **Equitable Access:** Efforts should be made to ensure that AR technologies are accessible to all stakeholders.

6.5 Limitations and Future Research

While this study provides valuable insights, it has certain limitations:

- Reliance on secondary data
- Lack of empirical validation through primary research
- Potential bias in data interpretation

Future research should focus on:

- Empirical studies involving practitioners and clients
- Long-term impacts of AR on sustainability
- Integration of AR with other digital technologies

In conclusion, AR represents a powerful tool for advancing sustainable space planning. By enhancing visualisation, engagement, and decision-making, AR addresses key limitations of traditional planning approaches. However, its successful implementation requires addressing technological, economic, and ethical challenges.

7. Conclusion

This study set out to explore the role of Augmented Reality (AR) in sustainable space planning through a qualitative analysis of secondary data, focusing on the perspectives of practitioners and clients. The findings demonstrate that AR represents a significant advancement in planning technologies,

offering enhanced capabilities for visualisation, communication, and decision-making. By bridging the gap between abstract design representations and real-world experiences, AR enables stakeholders to better understand and evaluate spatial interventions.

One of the key contributions of AR is its ability to improve spatial cognition and reduce ambiguity in design interpretation. This has important implications for both professionals and non-expert stakeholders, as it facilitates more informed and confident decision-making. Additionally, AR enhances participatory planning processes by making them more accessible, interactive, and inclusive. This aligns with the principles of collaborative planning and supports the development of socially sustainable outcomes.

From a sustainability perspective, AR contributes to the environmental, social, and economic dimensions of planning. It enables the simulation of environmental impacts, promotes inclusive stakeholder engagement, and improves efficiency by reducing the need for iterative design revisions. These benefits highlight AR's potential to support more sustainable and resilient urban development.

However, the study also identifies several challenges that must be addressed to fully realise the potential of AR. These include technological limitations, high costs, accessibility barriers, and ethical concerns related to data use. Addressing these challenges requires coordinated efforts from practitioners, policymakers, and technology developers. Investments in infrastructure, capacity building, and user-centred design

are essential for promoting the adoption of AR in planning practices.

The study contributes to the existing literature by providing a comprehensive analysis of AR's role in sustainable space planning and by integrating multiple theoretical perspectives. Nevertheless, the reliance on secondary data represents a limitation, highlighting the need for future research based on primary data collection and empirical validation. Further studies should also explore the integration of AR with other emerging technologies, such as artificial intelligence and digital twins, to enhance its impact.

In conclusion, AR holds considerable promise as a tool for advancing sustainable space planning. Its ability to enhance visualisation, engagement, and decision-making positions it as a key component of future planning practices. However, its successful implementation will depend on addressing existing challenges and ensuring that its benefits are accessible to all stakeholders.

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